Lagrangian Measurements of Eddy Characteristics in the California Current

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Long-Term Goals

Our overall goal is to understand better the kinematics and dynamics of mesoscale eddies found in the California Current system (CCS). Although this eastern boundary current has been the subject of many field studies, surprisingly little is known about these energetic surface-intensified current features and their role in the spatial and temporal variability of the CCS. We have used surface drifters plus remote sensing to accomplish this goal.

Objectives

We deployed satellite-tracked drifters off northern California to study the near-surface flow regime and eddy field in the CCS. Trajectory data from these and other drifters which moved into the study region during the period 1993-1995 plus AVHRR and altimeter data are being analyzed to characterize the mean flow and its variability and to investigate the local dynamics of individual eddies through smaller-scale deployments, with the overall scientific objective being to understand better the dynamical role of the eddy field with respect to the California Current.

Approach

Our approach was to deploy drifters in two patterns, an incoherent array designed to obtain a statistical description of the CCS, and a coherent array designed to sample an individual eddy. The primary drifter used was the standard WOCE SVP (World Ocean Circulation Experiment Surface Velocity Program) drifter drogued with a holey sock centered at 15 m and tracked by Service ARGOS. The incoherent array consists of seven drifters spaced approximately 40 km apart along either 39° N or 39.5° N starting westward from 125° W. This spacing was chosen based on past drifter studies to give independent trajectories from time of launch. The incoherent array was deployed seven times between May 1993 and August 1994.

A single anticyclonic eddy was heavily sampled for about 14 days with 24 drifters during the coherent deployment of September 1993. The attempt to sample a cyclonic eddy using 13 drifters in the coherent deployment of July 1993 provided less than two days of eddy observations because of the extreme wind conditions during that period. The second deployment included five barometer drifters supplied by P. Niiler (SIO). Both coherent array deployments followed high-resolution SeaSoar surveys of the eddy features by other investigators.

In addition, trajectory data from drifters which moved into the study area during 1992-1995 were obtained from the WOCE SVP Data Center. After final editing, the combined drifter data set represents about 156 drifter years.

Tasks Completed

A total of 49 drifters were deployed in incoherent arrays in May, June, August, and November of 1993 and in February, May, and August 1994. A coherent array of 13 drifters was deployed in a cyclone in July 1993 and a coherent array of 24 drifters was deployed in an anticyclone in September 1993. Roughly half of these drifters were still working by May 1995, although many of these drifters had left the initial study domain (120-135° W, 25-45° N). Data for 105 drifters deployed in other programs were obtained from the WOCE Drifter Center in mid-1996. The final combined drifter data set is available via Internet, and an animation of the drifter position data can be seen at the Web site http: globec.whoi.edu/globec-dir/misc-data.html.

In addition, AVHRR data and altimeter data for 1993-1994 were obtained from T. Strub (OSU) and K. Kelly (UW).

Results

The combined drifter data set (Figure 1) clearly illustrates the general southward flow of the California Current and the dominance of eddy variability in the CCS. Since the mean Ekman currents at 15 m are relative small compared to the upper ocean geostrophic flows, the mean drifter velocity field (Figure 2) shows a broad California Current flowing south- and southeastward between 40-30° N, with a maximum current located near 125- 127° W. The drifter data supports the hypothesis that in this region the California Current has a coherent high-velocity core which meanders over several degrees in longitude (in analogy to the Gulf Stream south of New England). Both the meandering and the formation of eddies (due to instabilities of the velocity core) result in pronounced spatial and temporal variability in currents and in eddy kinetic energy (EKE) (as indicated by the principle axes shown in Figure 3). This variability is most pronounced between 35-

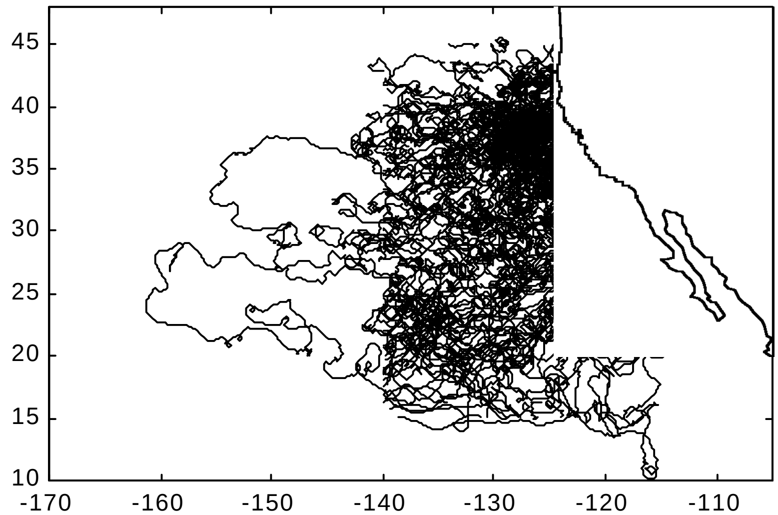

Figure 1. Low-pass filtered trajectories of the final combined EBC drifter data set.

39° N and 124-130° W, with a clear seasonal cycle with maximum EKE during late summer/fall (Kelly et al, 1997). Note that very few drifters approach within 100 km of the coast between Pt. Reyes (38° N) and Pt. Conception (34° N), and none cross onto the shelf in this latitude range. Whether this is a result of the meandering California Current core simply not reaching very close to the coast between 34-38° N or a strong offshore surface current is not known. The drifters generally turn west between 15-25° N, indicating that the northern edge of the North Equatorial Current was at 25° N, substantially northward of conventional wisdom.

Analysis continued with three general objectives, the first being a composite description of the variability of the EKE in the CCS based on altimetric, drifter and moored current data, the second a detailed statistical characterization of the CCS based on the drifter data, and the third a quantitative description of the translation and rotation behavior of individual mesoscale features within the CCS. Looping eddy trajectories have been identified in the data and, where possible, compared with dynamic height maps from the EBC large-scale surveys, AVHRR SST, altimeter-based surface geostrophic currents, and RAFOS data. One manuscript on EKE variability has been accepted for publication (Kelly et al, 1997), and a second manuscript presenting the drifter data in more detail is being prepared.

Impact for Science

Drifter measurements have the considerable advantage of measuring currents directly over a large spatial and temporal window. Thus, our results complement moored and shipboard current measurements and spatially smoothed measurements from satellite altimeters. In particular, Kelly et al (1997) combined the mean drifter velocity field with long-term mean hydrographic data from CalCOFI to produce a mean geostrophic surface

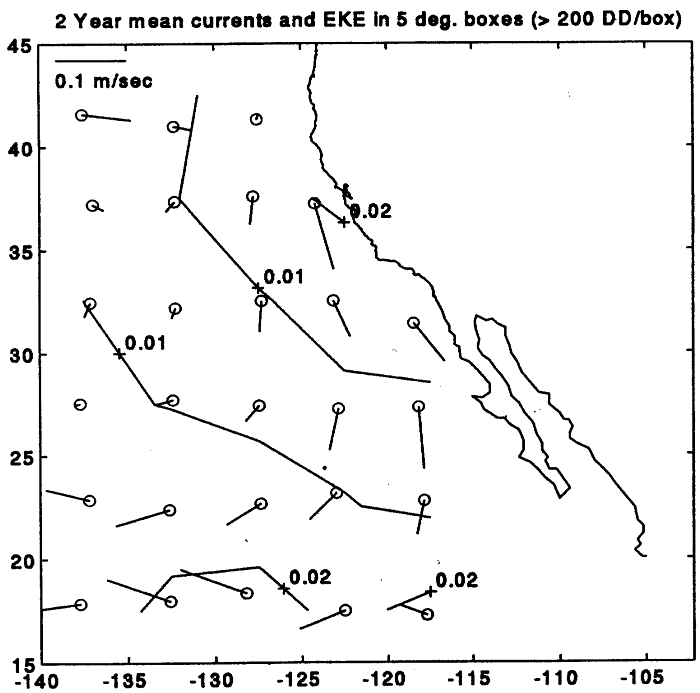

Figure 2. The time-averaged velocity and eddy kinetic energy (EKE) computed on a 5° by 5° grid over the period May 1993 - May 1995.

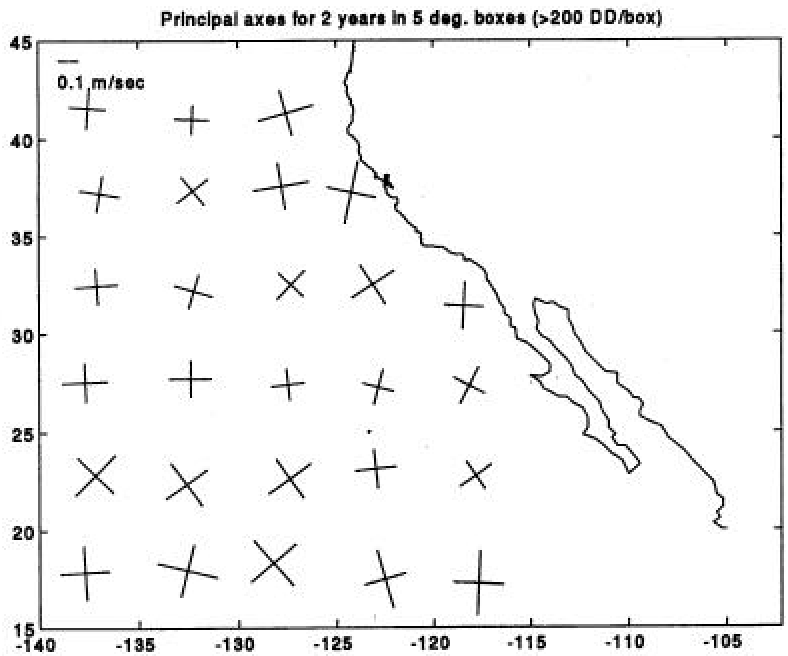

Figure 3. Current principal axes computed on a 5° by 5° grid over the same 2-year period.

current field and sea surface height field. This latter can then be used as the mean reference surface for altimeter-derived surface currents. The resulting "absolute" altimetric surface currents can then be used with drifter, AVHRR SST, and other data to study individual mesoscale features in detail. The combined measurements for the 1993-1995 time period present the most comprehensive picture to date of the near-surface currents and their variability in the California Current system.

Relationships to Other Programs

This work is part of the Eastern Boundary Current ARI program, and has been closely aligned with other physical and biological oceanographic investigations being made as part of that program.

References

Kelly, K.A., R.C. Beardsley, R. Limeburner, K.H. Brink, J.D. Paduan, and T.K. Chereskin, 1997. Variability of the near-surface eddy kinetic energy in the California Current based on altrimetric, drifter, and moored current data. J. Geophy. Res., accepted.